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APPARATUS FOR COLLECTING POLARIMETRIC GROUND PENETRATING RADAR DATA.

The present invention relates to an apparatus for collecting polarimetric ground penetrating radar data. In the following "polarimetric" is taken to mean with polarization information, i.e., containing information about the direction of the electric field of the radar wave.

Ground Penetrating Radar (GPR), also referred to as Ultra Wideband Radar, is a type of time domain radar system characterized by a high bandwidth. Typically commercial GPR systems have a fractional bandwidth in excess of 1.

In order to examine the properties of an area of ground, or more generally a test medium, a radar system is used wherein one antenna sends out electromagnetic signals and a second antenna registers the signals which reflect from the test medium. The registered information can be analysed to determine the properties of the test medium and to determine the location of objects which are buried in the medium. The transmitted signals vary depending upon the construction of the radar system. In special applications, a plurality of transmitters and receivers are used in a multi-channel system.

The transmitted electromagnetic waves have a number of properties which change as a result of passing through the test medium, reflecting against objects and reflecting against interfaces within the test medium. These properties include amplitude, frequency, phase and polarization and are used in order to build a better picture of the conditions in the test medium.

A linear, or more generally elongated, reflector polarizes all incoming electromagnetic fields so that the electromagnetic field is approximately parallel with the reflector subsequent to reflection. Consequently a radar system employing linearly polarised antennas registers the maximum amplitude when the transmitter and receiver are oriented parallel with the reflector and registers minimum amplitude when both antennas are perpendicular to the reflector. Intermediate positions between parallel and perpendicular give intermediate amplitudes. With different

orientations between the transmitter and receiver a variety of different results can be obtained. All of these situations can be analysed qualitatively by establishing that a maximum coupling to a linear reflector has been obtained when the antenna are parallel with said reflector regardless of whether it is a transmitter or receiver.

In order to use polarization information with a standard ground radar system, it is necessary to measure the test medium using a number of different orientations for the antennas, which can be ineffective and relies heavily on the precision of their positioning. A number of methods to simplify collection of polarization information have been suggested. All hitherto known methods are developments of the use of a number of antennas with different orientations requiring simultaneous measurement with these antennas. This type of solution has a number of inherent problems which must be addressed in order for the collected data to be useful. The operation of different transmitter – receiver pairs must be separated in time to avoid interference and its associated problems. Additionally, adjacent antenna elements cause reflection and interference with the desired signals. Different antennas also have different properties and these problems have a number of consequences for the construction of such a system. The antenna must be manufactured to be practically identical. This means higher production and construction costs. In practice, the antennas will always function slightly differently resulting in the processing of the information being more complicated or not as effective as possible. In order to use separate transmitter-receiver pairs a separate timing system is required compared with an ordinary ground radar system thereby increasing the complexity and overall cost of such a system. Additionally, interference from adjacent antenna elements makes the processing of information more complicated and the results less accurate and effective.

It is an object of the present invention to address the problems of the prior art including high manufacturing and production costs, additional costs associated with the provision of an extra timing device, the interference problems from adjacent antenna and the problems of accuracy associated with repositioning of antennas.

Accordingly, the present invention provides an apparatus for collecting polarimetric ground penetrating radar data comprising a main body having a means for moving the apparatus along the ground, a transmitter-receiver pair of antennas being

movably mounted on the main body for collection of ground radar data and a means for rotating the pair of antennas relative to the main body of the apparatus and the ground.

Ideally, the antennas are linearly polarised.

In one embodiment, the pair of antennas are fixed relative to one another and moved as a unit.

In another embodiment, the antennas are separately movable.

Rotation of the antennas in a controlled way allows collection of radar data with different antenna orientations. The facility for movement removes the need for a plurality of pairs of antennas and thus reduces the manufacturing costs and reduces the effects of interference from adjacent antenna pairs.

Preferably, the means for moving the apparatus along the ground is any vehicle capable of conveying the apparatus over terrain including motorised and non-motorised vehicles. The vehicle is controllable manually or remotely.

Ideally, the pair of antennas are enclosed in a housing. The housing includes screens and rf-absorbers to minimise the interaction between the transmitter and receiver antennas.

Preferably, a slip ring device electrically connects the antennas and a power source which is housed in the main body. The slip ring device provides continuous electrical contact between the power source and the pair of antennas.

Preferably, only digital control signals and DC voltages are transmitted through the slip ring device. Only simple signals are transmitted through the slip ring device and the number of signals which are transmitted through the slip ring device is minimised.

Ideally, analogue high-frequency electronic equipment associated with the transmitter and receiver antennas is mounted in the housing. The extra mass that

this includes is in practice negligible in comparison with the mass of the screens and rf-absorbers which are used to construct the antenna housing.

Preferably, a position/angle sensor determines the geometrical location of the antennas.

Ideally, the position/angle sensor communicates the geometrical position of the antennas to a control unit.

Ideally, movement of the antennas may be effected mechanically, electrically, hydraulically or pneumatically.

Additionally, the control unit controls the operation of the transmitter-receiver pair of antennas.

Preferably, the control unit can be programmed to measure polarisation information at an arbitrary number of antenna locations. A large number of orientations increases the time required to record the data, but the large amount of data makes possible more sophisticated translation of the collected data. The balance between the number of orientations and the speed of measurement depends on the specific task.

In another aspect of the invention, there is provided an apparatus for collecting ground radar data with polarization information comprising a main body having a means for moving the apparatus along the ground, a means for receiving a transmitter-receiver pair of linearly polarised antennas, the receiving means being movably mounted on the main body and a means for moving the receiving means relative to the main body of the apparatus and the ground.

The present invention will now be described with reference to the accompanying drawing, which shows by way of example only, one embodiment of an apparatus for collecting polarimetric ground radar data in accordance with the invention. In the drawing:-

Figure 1 is a schematic drawing of the apparatus.

The apparatus indicated generally by the reference numeral 1 includes a main body 2 and a portion 3 rotably mounted on the main body 2. The main body 2 of the apparatus 1 includes a control unit 4 and a power source 5. A slip ring device 6 and a position/angle sensor 13 are located intermediate the main body 2 and the portion 3. The portion 3 includes a transmitter 7 and a receiver 8. The transmitter 7 and receiver 8 antennas are coplanar and are enclosed within a housing 12. The transmitter antenna 7 has an associated pulse generator 9 and the receiver antenna 8 has an associated sampler 10 and an analogue to digital A/D converter 11. A drive unit (not shown) is used to rotate the antenna enclosure 12 relative to the main body 2.

In use, the main body 2 of the apparatus 1 is moved along the ground and the control unit 4 in response to a control programme sends trigger signals through the slip ring device 6 to the pulse generator 9. The pulse generator initiates the transmitter antenna 7 which emits electromagnetic waves into the ground below. The reflected radiation is received by the receiver antenna 8 and digitised by the sampler 10 and A/D-converter. The generated digital information is subsequently transmitted through the slip ring device 6 to the control unit 4. The information is optionally stored in the memory of the control unit 4 for later processing or may be processed in real time by an on board computer (not shown). The control unit 4 also controls the rotation or movement of the antennas 7, 8 enclosed in the housing 12. The position/angle sensor 13 provides the control unit 4 with the geometrical location of the antennas 7, 8.

It will of course be appreciated that the invention is not limited to the details of the specific embodiment which is given by way of example only and that various alterations and modifications are possible without departing from the scope of the invention as defined in the appended claims.

CLAIMS

1. An apparatus (1) for collecting polarimetric ground penetrating radar data comprising a main body (2) having a means for moving the apparatus (1) along the ground, a transmitter-receiver pair of antennas (7, 8) being rotably mounted on the main body (2) for collection of ground radar data and a means for rotating the pair of antennas (7, 8) relative to the main body (2) of the apparatus (1) and the ground.

2. An apparatus (1) as claimed in claim 1, wherein the antennas (7, 8) are enclosed in a housing (12).

3. An apparatus (1) as claimed in any preceding claim, wherein a slip ring (6) device electrically connects the antennas (7, 8) and a power source (5) which is housed in the main body (2).

4. An apparatus (1) as claimed in any preceding claim, wherein a position/angle sensor (13) communicates the geometrical location of the antennas (7, 8) to a control unit (4).

5. An apparatus (1) as claimed in claim 4, wherein the control unit (4) is operated by a control program.

6. An apparatus (1) as claimed in claim 4 or claim 5 wherein the control unit (4) controls the operation of the moving means for the pair of antennas (7, 8).

7. An apparatus (1) as claimed in any of claims 4 to 6 wherein the control unit (4) controls the operation of the transmitter-receiver pair of antennas (7, 8).

ABSTRACT

The present invention relates to an apparatus (1) for collecting polarimetric ground penetrating radar data. The apparatus (1) has a main body (2) incorporating a vehicle for moving the apparatus (1) along the ground. A transmitter-receiver pair of linearly polarised antennas (7, 8) are movably mounted on the main body (2) for collection of ground radar data. The pair of antennas (7, 8) can be rotated relative to the main body (2) of the apparatus (1) and the ground.

(fig)

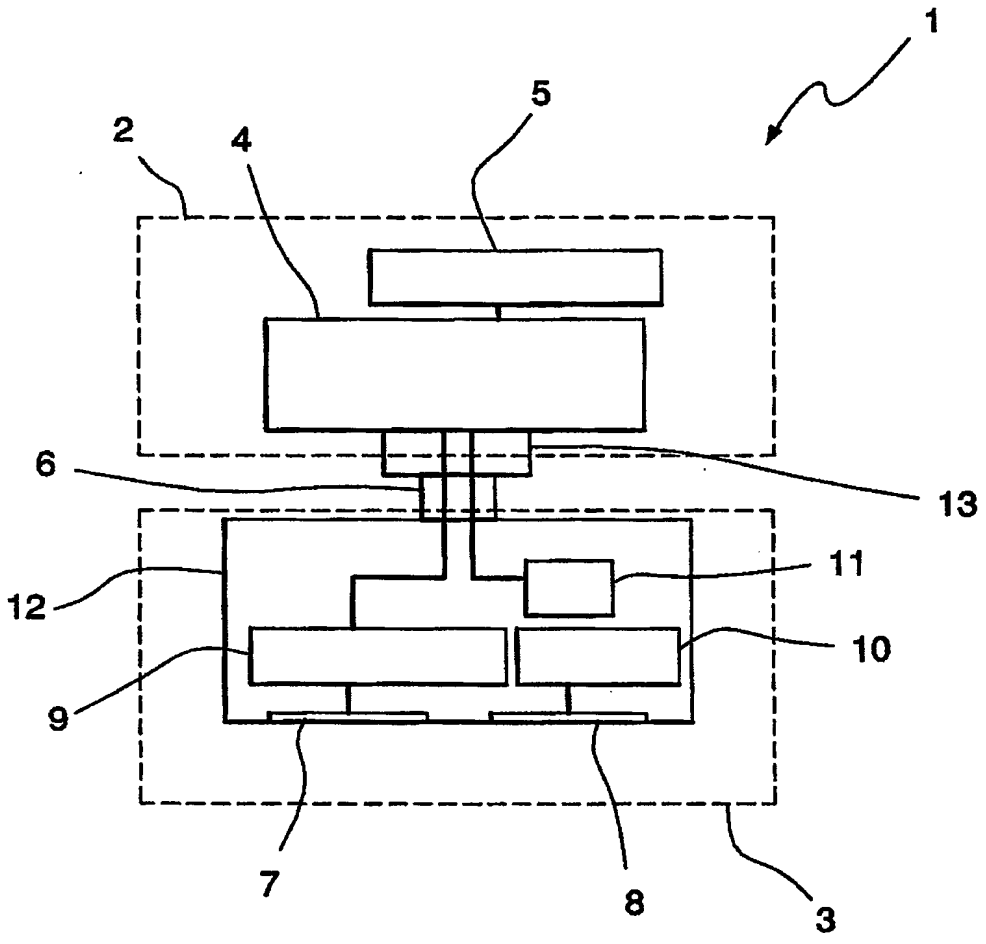

FIG.1